Construction and Intensive Field Testing of SEAS-II Sensors for Trace Element, Nutrient and CO2 System Analyses

Robert H. Byrne
College of Marine Science, University of South Florida
140 Seventh Avenue South
St. Petersburg, FL 33701
Phone: (727) 553-1508 Fax: (727) 553-1189 Email: byrne@marine.usf.edu

Eric A. Kaltenbacher
Center for Ocean Technology, University of South Florida
140 Seventh Avenue South
St. Petersburg, FL 33701
Phone: (727) 553-3959 Fax: (727) 553-3967 Email: eak@marine.usf.edu

Grant #: N00014-03-1-0612

LONG-TERM GOALS

This project is directed toward the deployment and testing of highly capable suites of chemical sensors in the upper ocean. The overarching goal of this project is a demonstration of the efficacy of SEAS-II sensors for real-time observations of critically important macronutrients, micronutrients and CO2 system variables in seawater. As a second-generation chemical sensor, SEAS-II will explore paths toward improved analytical sensitivity, rates of analysis and reliability.

OBJECTIVES

The reproducibility, sensitivity, accuracy and endurance of our sensors will be evaluated in the field by observations of sensor performance in vertical profiles over the upper 500-meter water column, and through observations of sensor performance at fixed sites for extended durations. This work is unique in that concurrent multiple-sensor deployments will be used to provide direct comparisons between identical types of sensors (identical analytes), and comparisons between different types of sensors (multiple analytes) whose observations can be linked via thermodynamic or biogeochemical models. This study aims to demonstrate that a single type of sensor can be interchangeably used for a wide variety of *in-situ* analyses in the same manner that a laboratory spectrophotometer is used for a wide range of colorimetric analyses.

APPROACH

Our work entails construction and intensive field testing of 10 SEAS-II sensors. Our SEAS-II field sensors will be used in two ways: (1) Four of our sensors will be used for long term deployments at fixed locations on open ocean and coastal moorings. The remainder of our SEAS-II field sensors will be used to obtain vertical profiles via hydrocasts in the upper 500 meters of the water column. In this mode SEAS-II sensors will be deployed and tested concurrently. As an example, two or more SEAS-II pH sensors can be used concurrently in hydrocasts to examine sensor reproducibility, while other

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
30 SEP 2003		**00-00-2003 to 00-00-2003**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Construction and Intensive Field Testing of SEAS-II Sensors for Trace Element, Nutrient and CO2 System Analyses	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **College of Marine Science, University of South Florida,,140 Seventh Avenue South,,St. Petersburg,,FL,33701**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT
This project is directed toward the deployment and testing of highly capable suites of chemical sensors in the upper ocean. The overarching goal of this project is a demonstration of the efficacy of SEAS-II sensors for real-time observations of critically important macronutrients, micronutrients and CO2 system variables in seawater. As a second-generation chemical sensor, SEAS-II will explore paths toward improved analytical sensitivity, rates of analysis and reliability.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**5**	

sensors can be used to obtain concurrent profiles of nitrate/nitrite/ ammonia and dissolved inorganic carbon. This type of testing program should provide stringent evaluations of sensor performance.

WORK COMPLETED

Using our extensive experience with SEAS-I instruments as a guide (Byrne et al., 1999, 2000, 2002; Kaltenbacher et al., 2000, 2001; Steimle et al., 2002; Waterbury et al., 1997) we have completed the design of a state-of-the-art analysis system, SEAS-II (Figure 1).

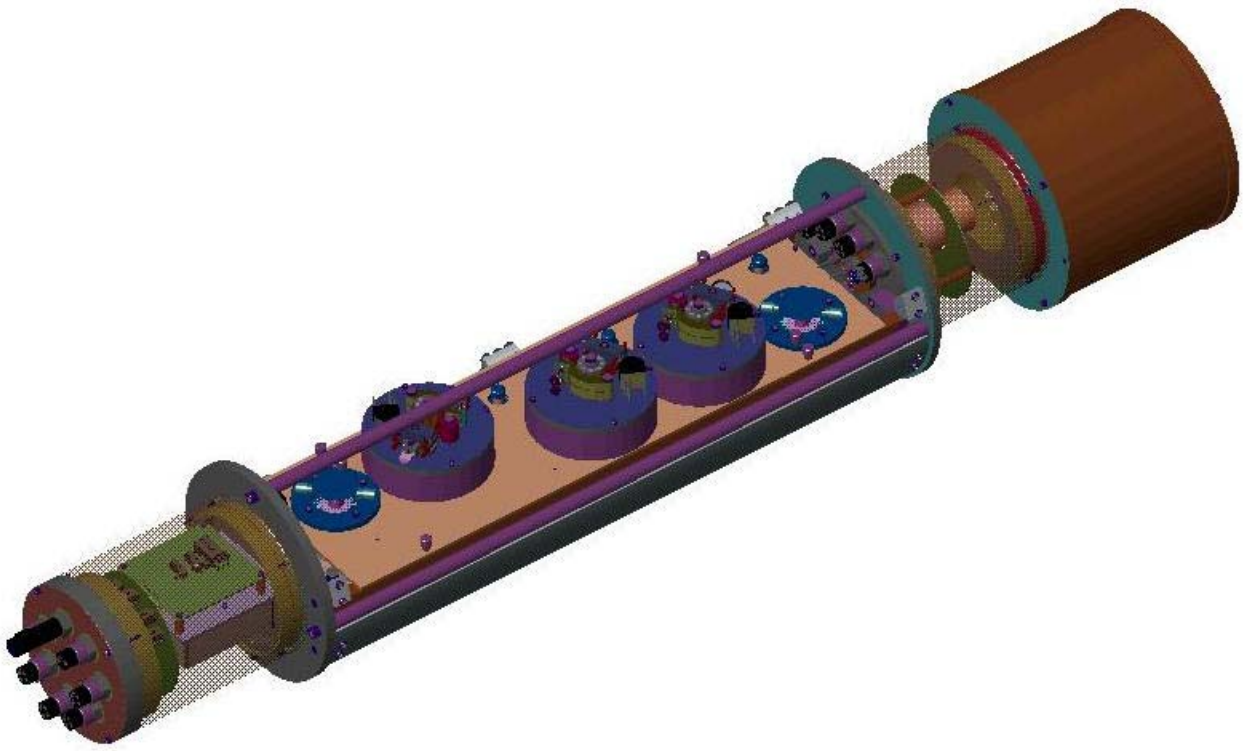

Figure 1: A 3-D model showing the design of SEAS-II (7" diameter x 40" long). The fluid-analysis system (pumps, valves, and waveguide) are all contained in the middle section of the instrument, which is not sealed from the surrounding environment.)

While the fundamental optical and chemical operations of SEAS-I and SEAS-II are identical, SEAS-II represents significant enhancement over our current instrumentation. Key areas of improvement include:

- Three times the number of fluid pumps
- Precise control of fluid delivery (+/- 1 microliter per minute)
- Simultaneous fluorescence and absorbance measurements
- Addition of fluid control valves
- Addition of a heater for improved reaction kinetics
- Completely self-contained (no external battery)
- Built-in interface for up to 4 external devices (e.g. CTD, fluorometer, another SEAS-II)
- Circuitry for instrumental self-tests.

Construction of the first SEAS-II is nearly complete and we expect to begin testing in late October or early November.

RESULTS

The expected outcome of this work will be development of exceptionally versatile, robust and sensitive *in-situ* chemical instruments for use by the oceanographic community. It is especially notable that SEAS-II sensors will be capable of measuring a very wide variety of key oceanic analytes.

IMPACT/APPLICATIONS

The distributions of chemical distributions in the upper water column are generally poorly resolved, in both a spatial and a temporal sense. Very few chemical sensors are capable of obtaining vertical profiles in the upper ocean. SEAS-II sensors are capable of resolving fine scale chemical variations in the upper ocean for a range of analytes. The simplicity and versatility of SEAS-II systems will strongly advance the oceanographic community's capability to obtain comprehensive chemical characterizations for suites of key oceanic parameters.

RELATED PROJECTS

This project is coordinated with ONR project N00014-96-1-5011 under the direction of Robert H. Byrne and Eric A. Kaltenbacher

REFERENCES

Byrne, R.H., Liu, X., Kaltenbacher, E.A. and K. Sell (2002). "Spectrophotometric Measurement of Total Inorganic Carbon in Aqueous Solutions Using a Liquid Core Waveguide", *Analytica Chimica Acta* 451: 221-229. [refereed]

Byrne, R.H., Kaltenbacher, E. and Waterbury, R. (1999), "Autonomous *In-Situ* Analysis of the Upper Ocean: Construction of a Compact, Long Pathlength Absorbance Spectrometer Aimed at Order-of-Magnitude Improvements in the Sensitivity of Spectrophotometric Analysis", *Sea Technology*, 40(2):71-75.

Byrne, R.H., Yao, W., Kaltenbacher, E. and Waterbury, R.D. (2000), "Construction of a compact spectrofluorometer/spectrophotometer system using a flexible liquid core waveguide," Talanta, 50:1307-1312. [refereed]

Kaltenbacher, E.A., Byrne, R.H. and Steimle, E.T. (2001), "Design and Applications of a Chemical Sensor Compatible with Autonomous Ocean Sampling Networks", *Journal of Oceanic Engineering,* 26(4):667-670. [refereed]

Kaltenbacher, E., Steimle, E.T. and R.H. Byrne (2000), "A compact, In-Situ, Spectrophotometric Sensor for Aqueous Environments: Design and Applications", *Proceedings of Underwater Technology*, pages 41-45, May 23-26 Tokyo, Japan.

Steimle, E.T., Kaltenbacher, E.A. and Byrne, R.H. (2002) "In-Situ nitrite measurements using a compact spectrphotometric analysis system", *Marine Chemistry* 77: 255-262. [refereed]

Waterbury, R., Yao, W., and Byrne, R. (1997), "Long Pathlength Absorbance Spectroscopy: Trace Analysis of Fe(II) using a 4.5 meter Liquid Core Waveguide", *Anal. Chim. Acta.*, 357:99-102. [refereed]

PUBLICATIONS

Due to the recent start date, no publications are directly attributable to this project at this time.